

April 12, 2002

MEMORANDUM FOR: John Williams  
Acting Project Director, Survey Section C

FROM: Charles W. Challstrom  
Director, National Geodetic Survey

SUBJECT: INSTRUCTIONS: Marksetting, Leveling, and GPS  
Observations at PUEBLO NDGPS CORS  
Site (GPS-1670)  
Task Number: BK6D0000

GENERAL:

The National Geodetic Survey (NGS) is establishing survey stations at the PUEBLO Continuously Operating Reference Station (CORS) site in Colorado. These stations must be tied to the CORS antenna at the site, as well as to the local Federal Base Network/Cooperative Base Network (FBN/CBN) through GPS observations. The CORS at this site serves as a Nationwide Differential GPS (NDGPS) site for the U.S. Coast Guard. This project will require three dual-frequency GPS receivers. Further, precise leveling will be performed.

PURPOSE:

The stations established at the site will provide a very accurate tie to the antenna as an aid to quickly reposition the antenna should it become necessary. The FBN/CBN tie observed during this project will also provide site station coordinates relative to the local FBN/CBN, thus reducing the potential for relative error between the stations and the local network. It will also provide a check on the FBN/CBN, relative to the CORS coordinates. The leveling will establish very accurate NAVD 88 heights for the survey stations at the CORS site.

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GPS SPECIFICATIONS:

Information concerning specific criteria for the sites is contained in Attachment 1. Station occupation and observing procedures shall be carried out in accordance with the "NGS Operations Handbook" and appropriate equipment user manuals. Data formats and digital file definitions are given in "Input Formats and Specifications of the National Geodetic Survey Data Base," Volume I, Horizontal Control Data, Federal Geodetic Control Subcommittee, September 1994. Success in meeting the accuracy standards will be based on repeatability of measurements, adjustment residuals, and analysis of loop misclosures.

General specifications for the project are given in "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques," Version 5.0: dated May 11, 1988, reprinted with corrections August 1, 1989.

Specific to this project is that at the site, two sessions of 2 hours each shall be observed at each station. In order to provide a check, the equipment shall be broken down and reset with a minimum of 30 minutes between the two sessions. Since the CORS site must be tied to the nearest FBN/CBN station, the FBN/CBN tie station (or backup station) must be occupied simultaneously with the two reference marks. The survey party shall check the NGS CORS Web page for information regarding CORS data availability immediately before and after the collection of GPS data. Data from the CORS site must be available for the scheduled occupation, otherwise, reobservations will be required.

GPS DATA ACQUISITION:

Data collection shall be accomplished at 15-second epoch intervals referred to the minute. The Trimble 4000 series receivers must collect data in the compressed mode as specified in the Trimble users manual. Track satellites down to a 10-degree elevation angle.

Record weather data at the beginning and end of the session. Meteorological data shall also be collected immediately after an obvious weather front passes during the session and immediately before it passes, if possible. Atmospheric

pressure and relative humidity measurements must be made at approximately the same height as the GPS antenna phase center. Record on the observing log the time and place that the weather data were gathered.

Antenna set-up is critical to the success of this project. Fixed-height tripods are preferred for all receivers. The plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when plumbing is performed. Plumbing bubbles must be shaded for 3 minutes before checking and/or re-plumbing. The perpendicularity of the poles must be checked at the beginning of the project and any other time there is suspicion of a problem.

When a fixed-height tripod is not used, the height of the antenna must be carefully measured to prevent station set-up blunders. Tribrachs used for these set-ups must be checked and adjusted when necessary. Totally independent measurements of the antenna height above the mark in both metric units and English units must be made before and after each session. Someone other than the observer must check the measurement computations by carefully comparing measurements and then entering his/her initials on the log.

A legible rubbing of the marks must be made at the time of the first occupation of a station. When not feasible to make the required rubbing, a plan sketch of the mark must be substituted, accurately recording all markings. There are new requirements for collecting digital photos of marks, as specified in "REQUIREMENTS FOR DIGITAL PHOTOGRAPHS OF SURVEY MARKS AND CORS ANTENNAS", Version 10, January 25, 2002. In addition, a layout sketch of the facility should be made. Include the location of the marks, antennae, buildings, and any other identifying characteristics of the area on the sketch, as well as the approximate height of the CORS antenna. Take photographs of the CORS antenna, site layout, reference stations, and any unusual situations.

The success of this project requires that the highest quality GPS data be collected. Therefore, during each station occupation, the operators shall carefully monitor the operation of the receivers. Any irregularities in the data due to equipment malfunction, DOD adjustment of the satellite orbit, obstructions, etc., must be reported to N/NGS41 as soon as possible. If the quality of observations for an observing session is questionable, notify N/NGS41.

VECTOR COMPUTATIONS:

Data management, quality review, and final vector processing will be accomplished using PAGES. Vectors will be computed in the International Terrestrial Reference Frame (ITRF) using the most current epoch and precise ephemerides. Use 30-second epoch interval for processing. The GPS data and positions for the antenna are available from NOAA's CORS GPS network. Monument positions will be used for CORS when available, otherwise, antenna reference point (ARP) positions will be used as the reference station. Use 15 degrees as the cutoff angle in data processing. A cutoff angle of 10 degrees may be used when necessary to improve results.

The type of final solution, L1 versus ion-free, will depend on the length of the vectors. For vectors from the antenna to the other stations at the site that are less than 5 km in length, the final reduction will consist of an L1 fixed solution. For the local FBN/CBN tie, there will be vectors computed from the antenna to the ties which are greater than 5 km in length. These vectors will be computed in a separate processing session from the short (less than 5 km) vectors.

In general, vectors greater than 10 km in length are to be computed in an ion-free fixed, or partially-fixed, solution. In all cases, integer ambiguities will be fixed for each vector whenever possible.

The quality of collected data shall be determined from the plots generated from PAGES and by analysis of repeated vectors and/or comparison of station positions, and free adjustment residuals and/or loop misclosures.

Perform all quality checks for conformance with NGS format standards such as executing software programs COMPGB, OBSCHK, and OBSDES. The final ITRF vectors will be assessed and transformed to the NAD 83 coordinate system using program ADJUST. The NAD 83 position for the CORS antenna will be used in the adjustments as the constraint. For the other stations, compare the computed NAD 83 positions to the published NAD 83 positions, if available.

The data and results will be submitted to the Observation and Analysis Division. All B-files and G-files must be complete, including \*25\* and \*27\* records.

GPS DATA:

Observing windows shall be selected and modified as necessary, to maximize satellite visibility for each session.

The project report and GPS data listed in Appendix L, Volume I, of "Input Formats and Specifications of the NGS Data Base" must be transmitted to the Field Operations Branch. Any data considered suspect as to quality in achieving accuracy standards should be sent by FedEx or express mail immediately for office review. Backups of transmitted data must be held until notified by the Field Operations Branch.

For the PUEBLO project, the data set collected shall be named "cond032d.945". All records in connection with the project shall be titled "PUEBLO NDGPS CORS SITE SURVEY, 2002". The project number is GPS-1670.

LEVELING DATA FORMATS AND HANDLING:

- A. Leveling data will be submitted in "Blue Book" format (see "Input Formats and Specifications of the National Geodetic Survey Data Base," Volume I. Horizontal Control Data (revised November 1998) and Volume II. Vertical Control Data, Federal Geodetic Control Subcommittee, September 1994) to NGS Headquarters on floppy disks. Floppy disks shall contain the final version of the following files: HGF, HGZ, and HA in direct access format and RPT and ABS in sequential format. Data shall be submitted to the Observation and Analysis Division within 30 days of completion of the project.
- B. All bench marks established during this leveling project must be plotted on the best available map and the positions of bench marks scaled using standard procedures, if the bench mark position cannot be determined with a GPS instrument. One set of these maps shall be submitted with the data. Those recovered bench marks which do not have PIDs will be treated as new marks.

STATION DESCRIPTIONS:

Station recovery notes must be submitted in computer-readable form using WDDPROC software. Include the name, address, and, if public ownership, the telephone number of the responsible party. Do not include the telephone numbers of private property owners.

LIAISON:

The street address of the following NGS offices in Building SSMC3 is:

1315 East-West Highway  
Silver Spring, MD 20910-3282

Questions concerning survey operations shall be directed to:

William T. McLemore, Jr.  
Chief, Field Operations Branch  
Observation and Analysis Division  
SSMC3 -- N/NGS41, Station 8564  
Telephone: 301-713-3215, ext. 117  
FAX: 301-713-4176  
E-mail: Bill.McLemore@noaa.gov

Questions concerning the GPS portion of the project shall be directed to:

Stephen J. Frakes or Robert J. Siclari  
Project Development Branch  
Spatial Reference System Division  
SSMC3 -- N/NGS21, Station 8853  
Telephone: 301-713-3194, ext. 111 or 130  
FAX: 301-713-4316  
E-mail: Steve.Frakes@noaa.gov or  
Bob.Siclari@noaa.gov

Questions and problems concerning adjustment processing should be directed to:

Maralyn L. Vorhauer  
Observation and Analysis Division  
N/NGS4, SSMC3, Station 8562

Telephone: 301-713-3176, ext. 104  
 Fax: 301-713-4327  
 E-mail: Maralyn.Vorhauer@noaa.gov

Questions and problems concerning vector processing should be directed to:

Juliana Blackwell  
 Field Operations Branch  
 Observation and Analysis Division  
 N/NGS41, SSMC3, Station 8458  
 Telephone: 301-713-3215, ext. 108  
 Fax: 301-713-4327  
 E-mail: Juliana.Blackwell@noaa.gov

Contact the site Point-of-Contact 3 or 4 days before arriving at the CORS site.

On-site contact:

Mr. Bob Bergeron or  
 Mr. Joe Vigil  
 Pueblo Army Depot  
 719-549-4672 or  
 719-549-4258

U.S. Coast Guard contact for Pueblo:

CWO Eric Shofner  
 U.S. Coast Guard  
 Supervisor, Shore Support  
 (DGPS) C2CEN  
 Portsmouth, VA 23703  
 Telephone: 757-686-4171  
 E-mail: Eshofner@C2CEN.uscg.mil

The NGS Geodetic Advisor for Colorado is:

Richard Cohen  
 325 Broadway  
 Boulder, Colorado 80303  
 Telephone: 303-758-9197  
 Fax: 303-757-9868  
 E-mail: fossilgps@aol.com

ADDRESS

Keep the Field Operations Branch informed of the party's physical address and telephone number at all times.

PUBLICITY:

See "NGS Operations Handbook," Section 1.4.1.

EXPENSES:

Expenses for this project will be charged to Task Number BK6D0000.

TRAVEL:

Travel and per diem are authorized in accordance with Federal Travel Regulations, Part 301-11, Per Diem Allowances. Current per diem rates were effective October 1, 2001.

ACKNOWLEDGMENT

Please acknowledge receipt of these instructions in your Monthly Report.

Attachments

cc: N/NGS - D. Zilkoski  
N/NGS - S. Misenheimer (first page only)  
N/NGS - D. Milbert  
N/NGS1 - G. Mitchell  
N/NGS1x1 - R. Cohen  
N/NGS21 - S. Frakes  
N/NGS21 - C. Craig (first page only)  
N/NGS21 - D. Hendrickson  
N/NGS4 - E. Wade  
N/NGS4 - D. Hoar  
N/NGS4 - M. Vorhauer  
N/NGS41 - W. McLemore  
N/NGS41 - J. Blackwell  
FGCS MEMBERS (first page only)  
U.S. Coast Guard - CWO Eric Shofner  
Pueblo Army Depot - Bob Bergeron  
Pueblo Army Depot - Joe Vigil



## Attachment 1

## PUEBLO CORS SITE

LEVELING CONNECTIONS:

Tie leveling to existing leveling lines, as described in the "Geodetic Leveling Manual," is required. CORS site reference stations PUB1 A and PUB1 B must be set if existing suitable stations cannot be found. The two new reference stations should be connected to L24883. Bench marks W 436 (PID JK0888), X 436 (PID JK0887), and Y 436 (PID JK0886) should be used for the three required tie marks. Total distance (progress) to be leveled is approximately 6 km, including tie leveling. Office abstracts for this line will be sent under separate cover.

All High Accuracy Reference Network (HARN) control points within 4 km of the leveling route and all other existing NSRS horizontal control within 1 km of the leveling route will be connected to this project.

LEVELING SPECIFICATIONS:

The line shall be leveled in both directions to first-order, class II standards. Leveling in one direction is acceptable when leveling between old bench marks, provided the newly observed elevation difference agrees with the previous difference within tolerance limits. When new marks are set, or the newly observed elevation difference between two old marks does not agree with the previous difference within tolerance, one side of the new or moving mark must be leveled in both directions.

In addition, if multiple new marks are set between old marks, all but one section between the old marks are to be leveled in both directions. Specifications and other technical considerations for this project are given in the "NGS Operations Handbook," "Geodetic Leveling Manual," "Bench Mark Manual," and "Interim FGCS Specifications and Procedures to Incorporate Electronic Digital/Bar-Code Leveling Systems."

MARK SETTING:

In general, the two CORS reference marks must be suitable for GPS occupation and be located within 1 km of the CORS antenna site. They must be at least B-stability, with A-stability preferred. The minimum quality mark set shall be a GPS 3-D monument. The CORS mark should be set as close as possible to the CORS antenna. These marks are not established to obtain azimuth with optical surveying equipment. The purpose of these marks is to provide redundant reference marks for referencing the CORS antenna at the facility.

LEVELING PROJECT TITLE, HGZ NUMBER, AND JOB CODE:

- A. The leveling project title, HGZ number, and job code shall be named, respectively:

PUEBLO NDGPS CORS SITE SURVEY 2002, NEAR PUEBLO, COLORADO  
L26364  
G5

## CORS SITE REFERENCE AND FBN STATION

PUEBLO	FBN station BLUE AZ MK,
	PID HK0591